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UPDATE NOTICE

LA36 DECwriter II Maintenance Manual

EK-LA36-MM-001

November 1976

Insert this Update Notice page in the *LA36 DECwriter II Maintenance Manual* (EK-LA36-MM-001) as a means of maintaining an up-to-date record of changes to the manual.

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INSTRUCTIONS

Remove pages 7-35 through 7-48 of the LA36 DECwriter II Maintenance Manual (EK-LA36-MM-001); these pages are now Chapter 21 in the *LA36 DECwriter II Maintenance Manual, Volume II* (EK-2LA36-MM-001). Also, the following pages are to be placed in the manual as replacement pages for current pages:

Old Page	New Page
1-5/1-6	1-5/1-6
1-9/1-10	1-9/1-10
1-11/1-12	1-11/1-12
2-5	2-5
3-1/3-2	3-1/3-2
3-3/3-4	3-3/3-4
4-9/4-10	4-9/4-10
4-13/4-14	4-13/4-14
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5-13/5-14	5-13/5-14
5-15/5-16	5-15/5-16
5-19/5-20	5-19/5-20
5-29/5-30	5-29/5-30
5-35/5-36	5-35/5-36

Printed in U.S.A.

Table 1-2
ASCII Codes and Responses

		KEYBOARD OPERATIONS			RECEIVE OPERATIONS	
		To Transmit, Type Key(s)				
ASCII Code	Character	SHIFT*	CTRL*	CHAR	Character Printed	Action/Description
000	NUL	√	√	SPACE	None	None
001	SOH		√	A		
002	STX		√	B		
003	ETX		√	C		
004	EOT		√	D		
005	ENQ		√	E		
006	ACK		√	F		None
007	BEL		√	BELL		Sound Alarm Bell
010	BS		√	H		Backspace one position
011	HT		√	I		None
012	LF		√	J		Advance Paper one line
013	VT		√	VT		None
014	FF		√	FF		None
015	CR		√	M		Move print head to left margin
016	SO		√	N		None
017	SI		√	O		
020	DLE		√	P		
021	DC1		√	Q		
022	DC2		√	R		
023	DC3		√	S		
024	DC4		√	T		
025	NAK		√	U		
026	SYN		√	V		
027	ETB		√	W		
030	CAN		√	X		
031	EM		√	Y		
032	SUB		√	Z		
033	ESC		√	[		
034	FS		√	\		
035	GS		√	=		
036	RS	√	√	~		
037	US	√	√	—	None	None
040	SP			space bar	Blank Space	Print character, move print head one position to the right.

*A check in this column indicates the key (SHIFT or CTRL) that must be held down while the character key is typed. If both keys are checked, then both keys must be held down.

Table 1-2 (Cont)
ASCII Codes and Responses

		KEYBOARD OPERATIONS			RECEIVE OPERATIONS	
		To Transmit, Type Key(s)				
ASCII Code	Character	SHIFT*	CTRL*	CHAR	Character Printed	Action/Description
041	!	√		!	!	Print character, move print head one position to the right.
042	"	√		"	"	
043	#	√		#	#	
044	$	√		$	$	
045	%	√		%	%	
046	&	√		&	&	
047	'			'	'	
050	(	√		(	(	
051	)	√		)	)	
052	*	√		*	*	
053	+	√		+	+	
054	,			,	,	
055	-	√		-	-	
056	.			.	.	
057	/			/	/	
060	0			0	0	
061	1			1	1	
062	2			2	2	
063	3			3	3	
064	4			4	4	
065	5			5	5	
066	6			6	6	
067	7			7	7	
070	8			8	8	
071	9			9	9	
072	:	√		:	:	
073	;			;	;	
074	<	√		<	<	
075	=			=	=	
076	>	√		>	>	
077	?	√		?	?	
100	@	√		@	@	
101	A	√		A	A	
102	B	√		B	B	
103	C	√		C	C	
104	D	√		D	D	Print character, move print head one position to the right.

*A check in this column indicates the key (SHIFT or CTRL) that must be held down while the character key is typed. If both keys are checked, then both keys must be held down.

1.2.4 Ribbon Drive System

A 40-yard, 0.5-in. wide ribbon is wound upon two 3-1/4 in. diameter spools. Two rivets are provided in the ribbon, one near each end, to serve as a reversing tripper.

Power from the carriage drive motor moves the ribbon through a drive belt and a one-way clutch and a reversing mechanism. The clockwise motion of the motor during printing is used to drive the ribbon; no ribbon motion occurs during carriage return. The drive is *always* connected to one of the two spools. The connecting mechanisms are controlled by a power shift which is triggered by the reversing sensors. As one spool empties, the rivet on the ribbon pushes a lever into the path of a shift tab which flips the ratchet from one reel to the other. Ribbon tension of 3 oz. is maintained by drags composed of spring-loaded disk brakes on each spool hub.

1.2.5 Carriage Servo System

The Carriage Servo System is a dc servo mechanism that contains a power amplifier driving a conventional permanent-magnet dc motor which drives the carriage through a timing belt. The movement of the motor shaft and hence the position of the carriage is detected by an optical incremental encoder which produces one pulse for each 0.01 in. of carriage motion.

A one-decade, up/down BCD (Binary Coded Decimal) counter keeps track of the carriage position within a character space. The overflow of this counter is monitored by a MPC and is used to determine the carriage position and for other control functions. The speed of the motor during printing, carriage return, and LCV (Last Character Visibility) is controlled by the MPC by means of a register which in turn controls the output voltage of the power amplifier feeding the motor.

Printing is accomplished by moving the print head from left to right across the space to be occupied by the character. When a BCD counter indicates that the carriage is at a given dot position, the appropriate solenoids are energized to print. If the carriage is to the right of the starting position for the character, the carriage is moved to the left of the starting position before printing commences. If there is a second printing character in storage while a character is being printed, the carriage speed is increased to catch up. When printing is complete, the carriage stops.

When a backspace character is received, the carriage is moved to the left a distance of one character cell (0.1 in.). This function allows character overprinting without an intervening carriage return.

When a carriage return character is received, the carriage is moved to the left-hand margin. Carriage speed is a function of the distance between the carriage and the left-hand margin. The time required to return the carriage to the margin is compensated for by an accelerated print rate until no more than one character is in the buffer.

When approximately two seconds have elapsed without a printable character input, the carriage moves four character spaces to the right to permit the operator to see the last character. When printing is to be resumed, the carriage moves to the left to begin printing.

1.2.6 Power Supply

The main power supply is an unregulated supply with nominal output voltages of +21 Vdc and −21 Vdc. The minimum instantaneous output voltage is 15 V for full load and minimum line voltage.

The 5 V supply for the logic has a regulation of ±5% with 200 mV p-p maximum ripple.

Regulated voltages of +12 V ±5% and −12 V ±5%, with 500 mV p-p maximum ripple are provided for operational amplifier and MOS (Metal Oxide Semiconductor) circuits. A −9 Vdc regulator is included on the Logic Board when the PROM (Programmable Read Only Memory) option is supplied.

1.2.7 Standard Current Loop Interface

The standard interface is a full-duplex, passive 20 mA current loop similar to a Teletype® interface. The cable pin connections are shown in Table 1-3 (polarities denote current flow) and Figure 1-3. Circuit operation is shown in Figure 1-4. (Polarities denote current flow.)

Table 1-3
Standard Full-Duplex
20 mA Current Loop Cable Connections

Connector Pin Numbers		Circuit	Description
To Logic Board Connector J3	To Host Computer Connector		
P1–2	P2–3	Transmit (+) (keyboard)	Negative side of line
P1–5	P2–7	Transmit (−) (keyboard)	Positive side of line
P1–3	P2–2	Receive (+) (printer)	Negative side of line
P1–7	P2–5	Receive (−) (printer)	Positive side of line

Typing each specific key causes the LA36 transmitter switch to be opened and closed in a pattern that defines the key.

The 20 mA communications circuit will operate wherever the current source is located. A device is said to be *active* if it supplies the current for the communications loop and *passive* if it receives current from another device.

The LA36 is shipped with a 20 mA cable (BC05F) to interface the terminal as a passive device to a computer, or to another peripheral device that is operating as an active device.

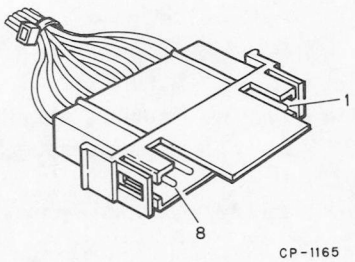

Figure 1-3 Current Loop Cable Connector Pin Designations

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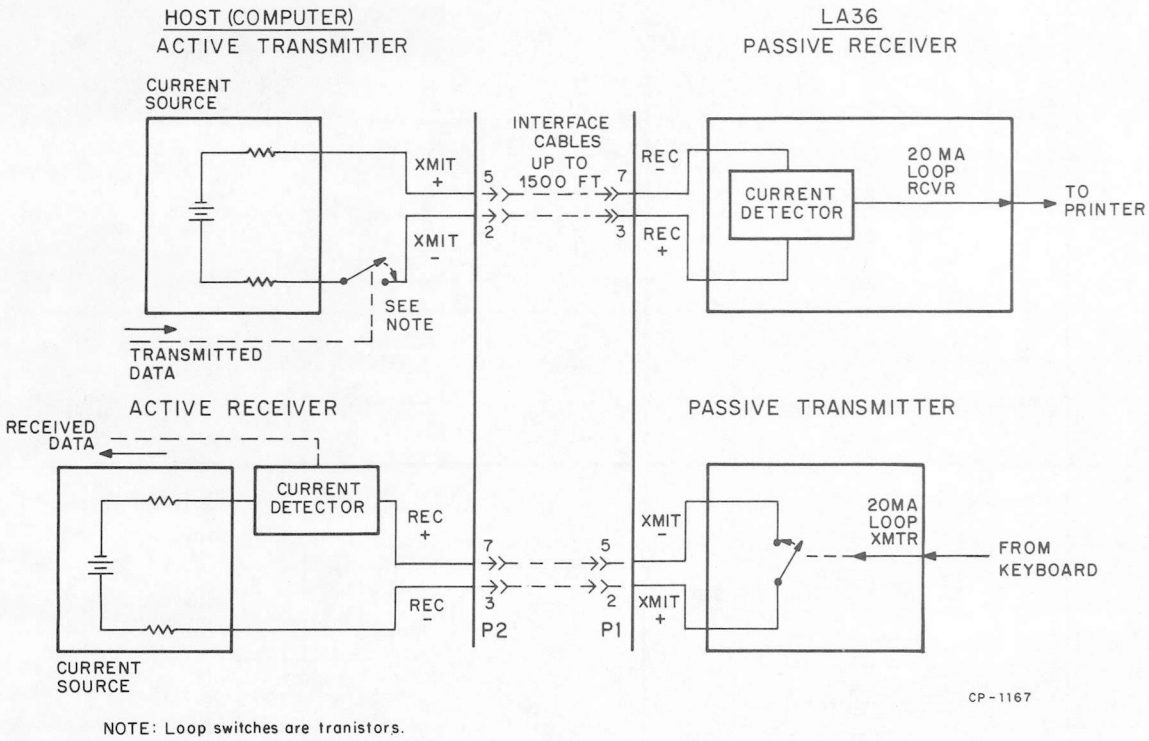


Figure 1-4 Standard Current Loop Interface

1.2.8 Optional Half-Duplex, (Active or Passive) Current Loop Interface

In the half-duplex mode, transmission between two devices can take place in only one direction at a time; however, no keyboard lockout is provided. Any of the configurations shown in Figure 1-5 can be obtained by using jumpers on LA36 Logic Boards; the jumpers can be changed as described in Chapter 2 Section 2.5.4. The configurations on the left of the diagram show the LA36 used as an active device, providing its own current source; the configurations on the right show it being used in the half-duplex mode, both as a passive and an active device.

Cable pin connections are shown in Table 1-4.

Table 1-4
Optional Half-Duplex
20 mA Current Loop Cable Connections

Connector Pin Numbers		Circuit	Description
To Logic Board Connector J3	To Host Computer Connector		
P1–5	P2–3	Transmit (+) (keyboard)	Negative side of line
P1–3	P2–5	Receive (-) (printer)	Positive side of line

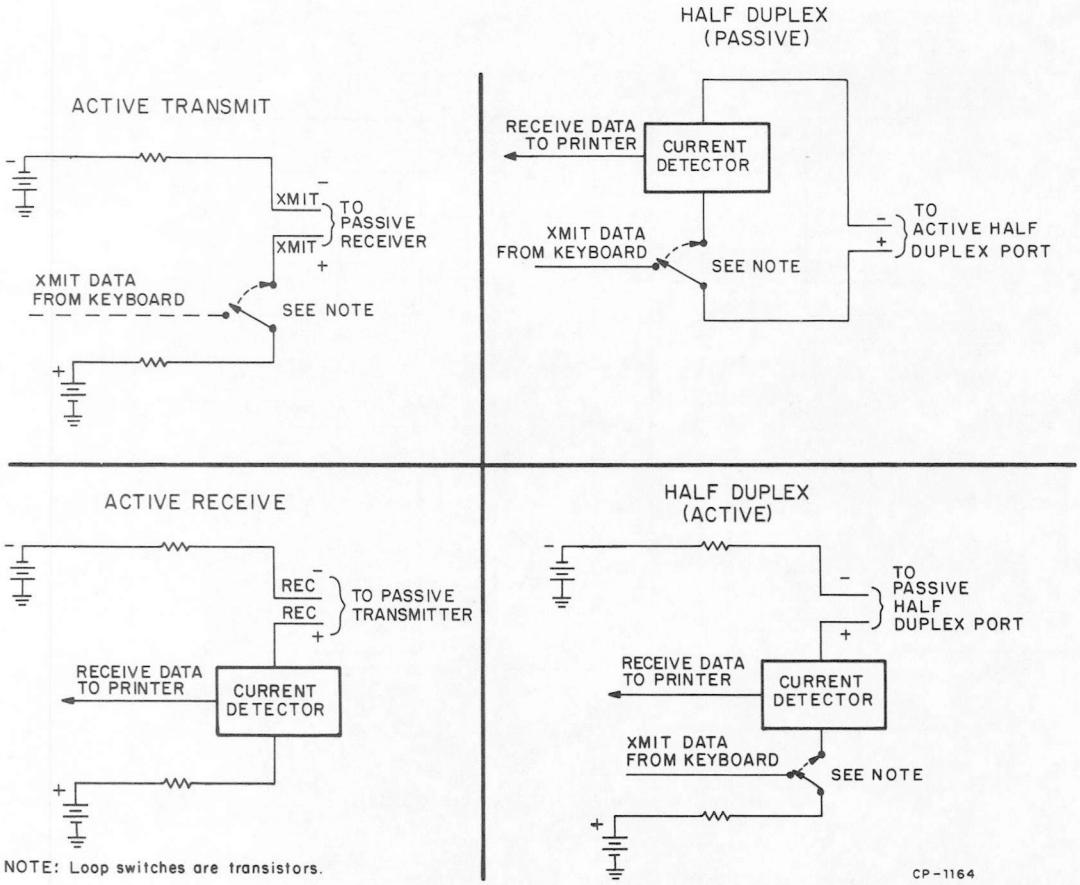


Figure 1-5 Optional Current Loop Configurations

The active connection defeats the isolation of signal line and local circuits, requiring that appropriate protective measures, such as high potential breakdown grounds (lighting arrestors, etc.) be installed on the signal line and that care be taken to ensure that protective (frame) ground is connected.

1.2.9 Peripheral Interface Port

The LA36 has a connector for non-current loop interfaces. The connection is via a straight 8-pin Mate-N-Lok connector, J4, with the pin designations listed in Table 1-5.

The interface using this port is physically mounted within the LA36 cabinet.

1.3 TECHNICAL CHARACTERISTICS

The technical characteristics of the LA36 DECwriter II are listed in Table 1-6. The interface specifications for the LA36 serial 20 mA current loop are shown in Table 1-7.

1.4 OPTIONAL FEATURES AND ACCESSORIES

Optional features and accessories are listed in Table 1-6.

1.4.1 EIA/CCITT Interface

The LA36 is optionally available with interfacing capability that complies with the requirements of EIA Standard RS-232-C and CCITT Recommendation V-24. It is supplied with a 9-ft cable terminated in a standard EIA connector (Figure 6-53). The cable mounts through the interface opening in the bottom of the LA36 chassis and plugs into connector J4 on the LA36 Logic Board. Connector pins are shown in the Table 1-8.

Table 2-2
Current Loop Configuration Jumpers

Jumper	W2	W3	W4	W5	W6	W7	W8	W9	W12	W32	W54
Full-Duplex Active	0	0	0	0	1	1	1	1	0	1	1
Full-Duplex Passive	1	1	1	1	0	0	0	0	0	0	0
Passive Receive/ Active Transmit	1	1	0	0	1	0	1	0	0	0	1
Active Receive/ Passive Transmit	0	0	1	1	0	1	0	1	0	1	0
Half-Duplex Active*	1	1	1	1	1	0	0	1	0	0	0
Half-Duplex Passive*	1	1	1	1	0	0	0	0	0	0	0

*Connect user-manufactured cable between J3-3 and 5 and operating system.

Legend: 1 = Jumper inserted
0 = Jumper not inserted

5. Set the BAUD RATE switch to 300 and the LINE/LOCAL switch to LOCAL.

6. Press the LINE FEED key and then hold down the CTRL key and press the BELL key. The stepping motor should advance the paper one line and the bell tone should sound. If not, refer to symptoms 3 and 4a of Table 5-2.

7. Press the / (slash) or @ key and the REPEAT key. The print head should travel smoothly along the print bar and print the corresponding character. When the print head passes the 64th character position, the bell tone should sound. If the bell tone does not sound, refer to symptom 4b of Table 5-2. If the print head hangs up trying to print a character, refer to symptom 5 of Table 5-2. If other symptoms appear, look for the corresponding symptom in Table 5-2.

8. Press the BACKSPACE key. If the print head does not move one character position to the left, refer to symptom 13 of Table 5-2.

9. Press the RETURN key after 132 characters have printed and observe the return of the print head to the "home" (LCV) position. It should take approximately 1/2 second. If it takes longer, refer to symptom 12 of Table 5-2.

10. Set the BAUD RATE switch to the setting prescribed for the operating system.

11. Set the LINE/LOCAL switch to LINE and run customer-provided programs to check that the unit operates satisfactorily when connected to the system.

CHAPTER 3
OPERATION

3.1 OPERATOR CONTROLS

The LA36 DECwriter II operator controls are described in Table 3-1 and illustrated in Figure 3-1.

Table 3-1
Control and Function Keys

Control/Key	Description
CTRL Key	Holding down the CTRL key when a character is typed forces bits 6 and 7 of the ASCII code for the character to 0. For example, the ASCII code for the letter "g" is 147 (1100111) bits 7 and 6 Holding down the CTRL key and typing g transmits ASCII code 007 (0000111) bits 7 and 6 are forced to 0 The CTRL key enables the LA36 operator to transmit all ASCII control codes (000–037).
BREAK Key	The BREAK key is commonly used to forcibly interrupt the flow of data coming to the LA36. It is provided for users with software written for half-duplex operation. In half-duplex operation, only one set of lines exist between the terminal and the host computer. If the host computer has control of the lines, BREAK is the only means of forcing an interrupt.
POWER Switch	The POWER switch controls the ac line voltage to the LA36.
LINE/LOCAL Switch	The LINE/LOCAL switch connects the LA36 to the transmit and receive lines in the LINE position, and disconnects it in the LOCAL position.
ESC(SEL) Key	The ESC(SEL) key enables the LA36 operator to generate an Escape command. Standard programming conventions dictate that receipt of ESC (ASCII code 033) directs the receiving device to treat the next character as a command. Commands encoded in this manner are called *Escape Sequences.* It is the responsibility of the host computer programmer to define the exact Escape Sequence for each application.

Table 3-1 (Cont)
Control and Function Keys

Control/Key	Description
TAB Key	The TAB key generates ASCII code 011. The programmer must design the software to translate TAB commands into the proper number of space commands to be sent back to the LA36.
LINE FEED (LF) Key	The LINE FEED key generates ASCII code 012. The MPC advances the paper one line each time LF is typed. **NOTE** **Rapid off-line paper advance may be accomplished by placing the machine in LOCAL and depressing the LF and REPEAT keys simultaneously.**
BACKSPACE Key	The BACKSPACE key generates ASCII code 010. The microprogram moves the print head one position to the left each time the BACKSPACE key is typed.
RETURN Key	The RETURN key generates ASCII code 015. The microprogram positions the print head at the left margin each time the RETURN key is depressed.
REPEAT Key	The REPEAT key, by itself, transmits no code to a host computer. Holding down the REPEAT key and depressing a character key causes the ASCII code for the character to be transmitted repeatedly at 15 cps until either the REPEAT key or character key is released.
BAUD RATE Switch	The BAUD RATE switch controls the rate at which characters are transmitted and/or received. **Switch Position** — **Character Rate** 110 — 10 char/sec 150 — 15 char/sec 300 — 30 char/sec
Carriage Adjustment Lever	The carriage adjustment lever controls the print head gap for single- or multi-part forms.
Tractor Adjustment Knob	The Tractor Adjustment knob releases the tractor, allowing the use of paper of varying widths.
Paper Advance Knob	The Paper Advance knob pushes in and disengages the line feed gear train to allow fine vertical adjustment of paper position.
Ribbon	The ribbon reverses automatically. It must be periodically turned over and/or changed.

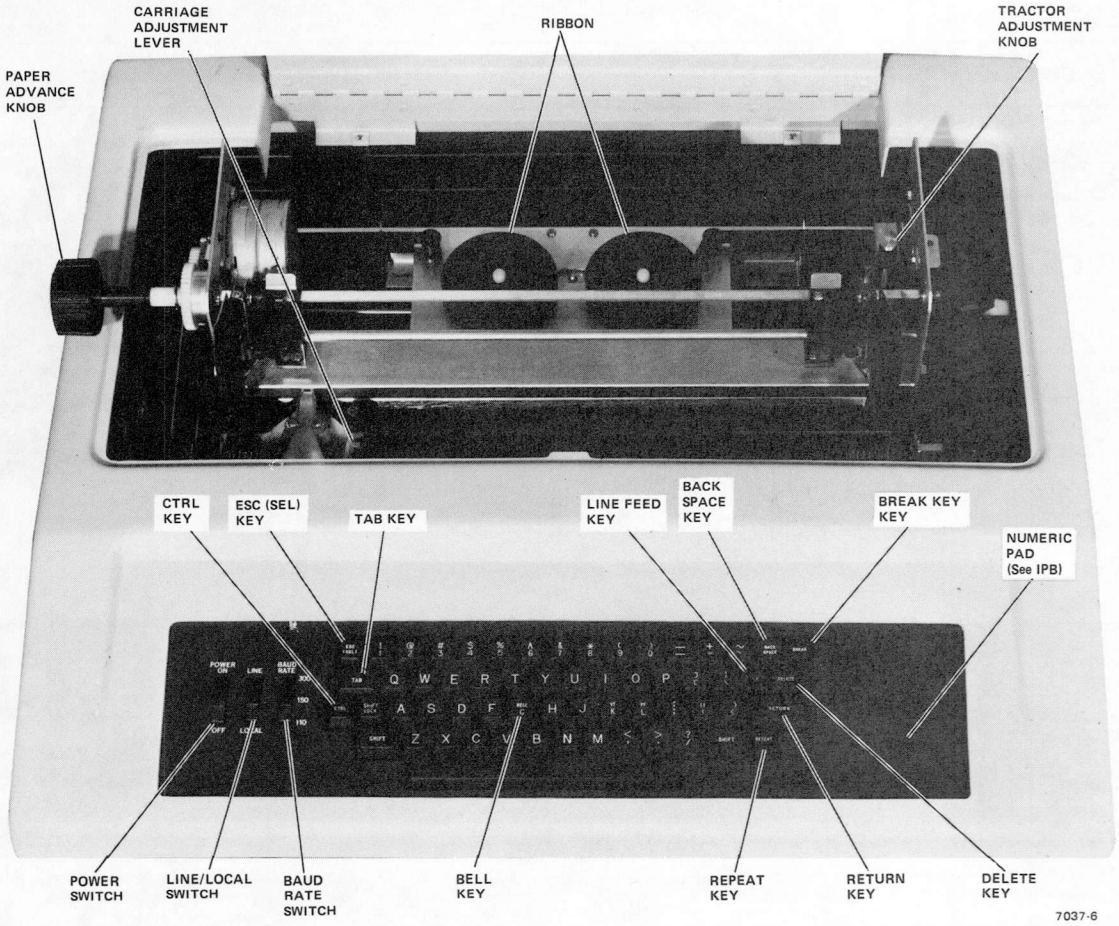


Figure 3-1 Operator Controls

3.2 OPERATING PROCEDURES

3.2.1 Loading Paper

1. Set POWER switch to OFF.

2. Move the Carriage Adjustment Lever (Figure 3-2) toward the keyboard as far as possible; this creates space for inserting paper.

3. Place tractor-feed paper on the floor between the legs of the LA36. (The term tractor-feed refers to the holes on either side of the paper.)

4. Feed the paper through the load channel under the terminal. Draw the paper up as it passes between the print head and the print bar (Figure 3-3).

5. Open both tractor covers (Figure 3-4) so that the tractor pins are exposed. Insert the left side of the paper with the holes aligned directly over the tractor pins. Close the left side tractor cover.

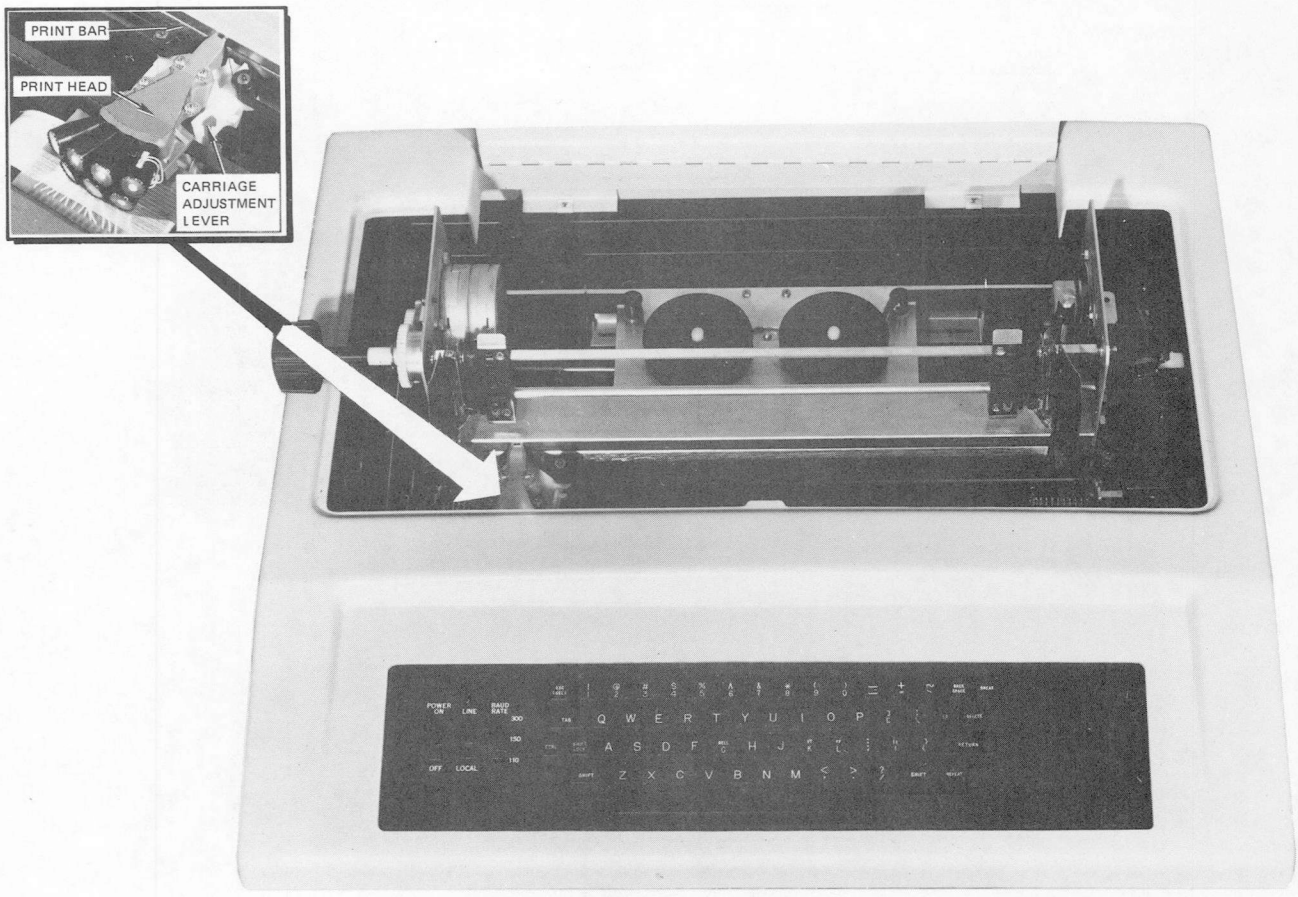


Figure 3-2 Carriage Adjustment Lever

6. Loosen the Tractor Adjustment Knob (Figure 3-4) on the right tractor (about 1/4 turn). The tractor will now slide freely to the left or right. Slide the tractor to a position where the holes on the right margin align directly over the tractor pins. Tighten the tractor adjustment knob and close the cover.

NOTE

In order to ensure proper paper feeding, do not tension paper too tightly. If tension is excessive, the following problems may occur:

1. **Paper holes will be distorted.**
2. **Paper may become dislodged from tractor.**
3. **Spacing between lines may become uneven.**

7. Adjust the carriage adjustment lever so that the print head is near, but not exerting pressure on the paper. There should be no friction between the paper and the print head as either moves.

   The right side of the carriage is numbered 1–7; positions 1–6 correspond (approximately) to 1–6 part forms.

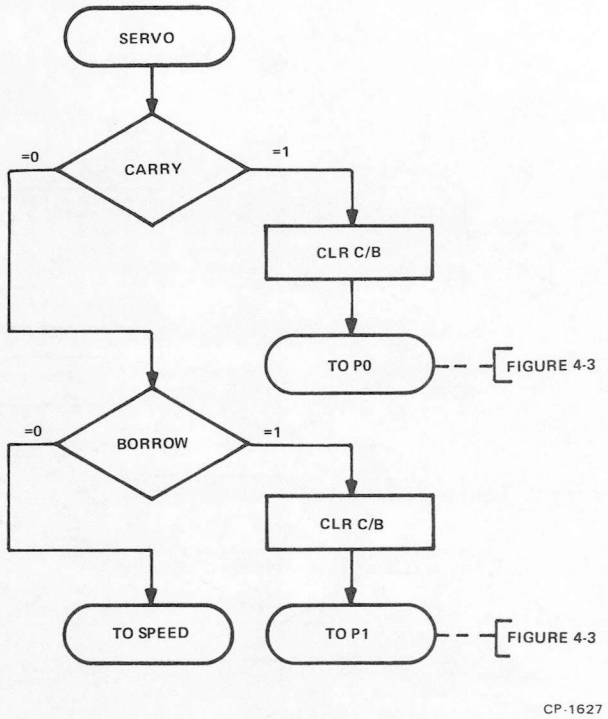


Figure 4-4 Servo Routine

Table 4-2
SPEED Algorithm

Count = 0 Print = 1	WD CT	Position	Speed (ips) + = Print - = Return Motion
		⩾ 16	-50
		⩾ 8	-30
		⩾ 4	-20
		⩾ 2	-10
		= 1	-6
= 0		= 0	0
= 1	= 0	= 0	+3
= 1	= 1	= 0	+6
	= 0	< 0	+3
	= 1	< 0	+6

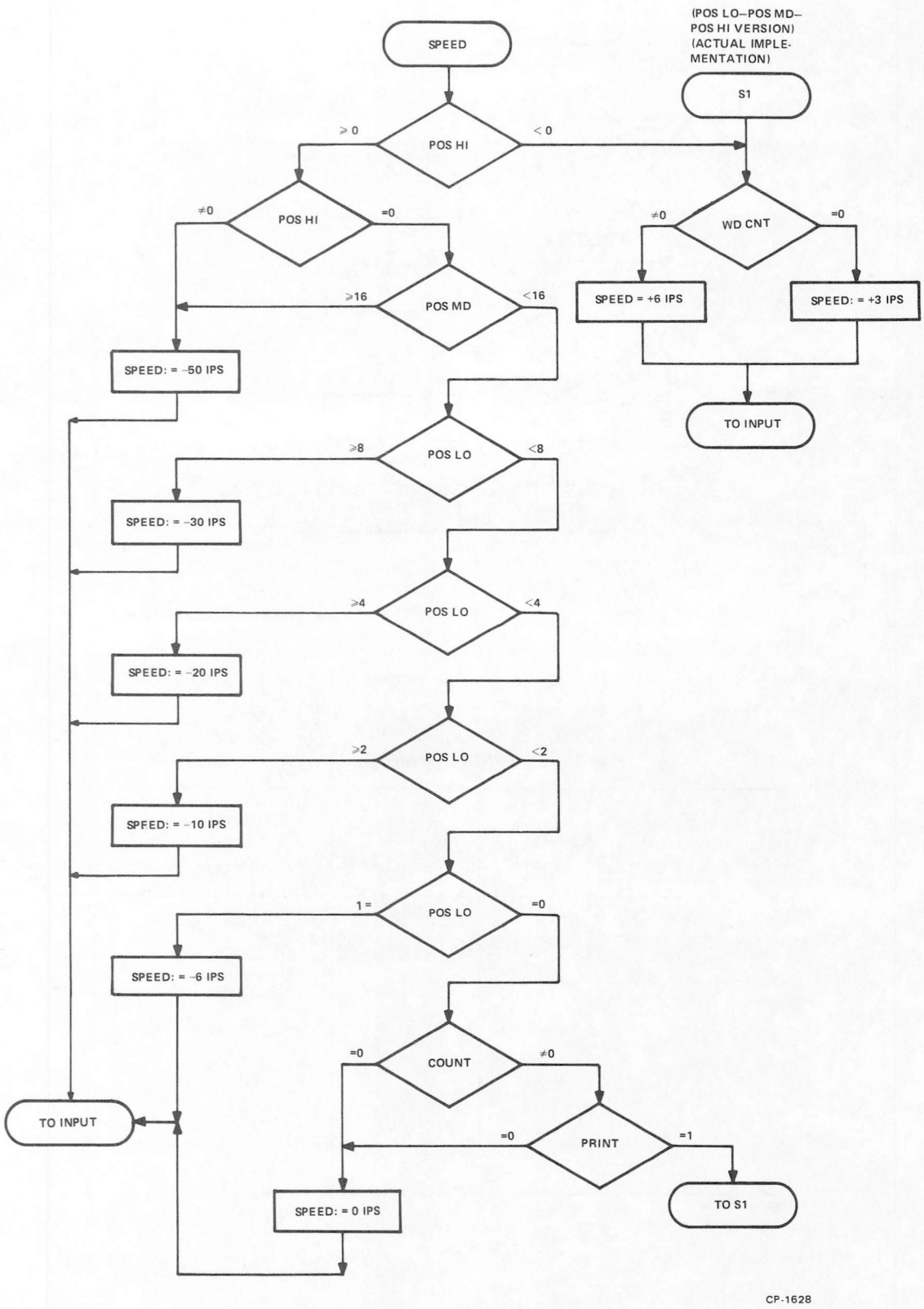


Figure 4-5 Speed Routine

If Bell Status is zero, no bells are required and the routine falls through to check Count, Print, and Word Count. Here the decision is made to process either a Print, a LF, or the next character, or to execute an LCV.

If Bell Status is not zero, the status is checked to see if it is odd or even (for each bell code received, two counts are stored in status, one to turn it on and one to turn it off).

The bell timers in location 15 and 16 provide 4-bits of each Count. The bits in either location 15 or location 16 are incremented during each pass until that timer has reached zero (106 ms) and Bell Status either becomes odd and the bell is turned off, or even and the bell is turned on. Each pass through the loop takes 416 μs and it takes 256 passes to fully cycle each timer, providing 106 ms of on time and 106 ms of off time. Each time a timer reaches zero, one is subtracted from Bell Status until the total number of bells commanded have been executed.

4.1.8 PRINT Routine

Before entering the PRINT routine (Figure 4-8), the program sequenced through the BELL routine where it found that the Count location was not zero and that the Print Bit in location 12 was set, indicating that a printable character was in the buffer. These conditions caused the program to enter the PRINT routine.

Upon entering the PRINT routine, the program checks the position locations to be sure that they are all equal to zero. This is done to prevent the start of print at some position other than the beginning of the character cell.

The program checks position from low order through high order in 4-bit bytes, and if any are non-zero, it checks Count and returns to the POSIT routine, looping until Count is less than the seven dot positions of a character. At this point it sets Count to zero, loops once more through POSIT and returns to PRINT.

In this pass, the program drops through to check Count again. This time Count should equal 8 as set in the NEXT routine. The program verifies this by checking the MSB of location 11 in the control RAM. If this bit is set, it signals the start of print (meaning that the head should start moving to the right). To start this motion, the program subtracts one from Position Error, sets Count to 7 (to prevent a repeat of this branch), and returns to POSIT to loop through again so that the SPEED routine can command head motion.

This time through, POSIT is still 0 relative to column, Count is less than 8 (7); the program presets the Print Timers, and clears the Increment indication. It waits then for Increment to set, and when it does it sets the 600 μs Head Drive Enable (HDE).

NOTE

At all other times through this routine, operation is synchronized on the 416 μs clock, but at this point continuation of program flow is predicated on the fact that an incremental motion of the head has been accomplished.

The 600 μsec HDE is then timed out in PT1 and PT2 locations of the control RAM on the 1.184 μsec instruction timing cycle of the microprogram. During this time the character is printed. At the end of that time, HDE is cleared, print is reset to 1, Count is set once again to −1, and the program reenters the POSIT routine.

4.1.9 LINE FEED Routine

If, while passing through the BELL routine, Count was not equal to 0 and the Print Bit in location 12 is cleared, the program enters the LINE FEED routine (Figure 4-9).

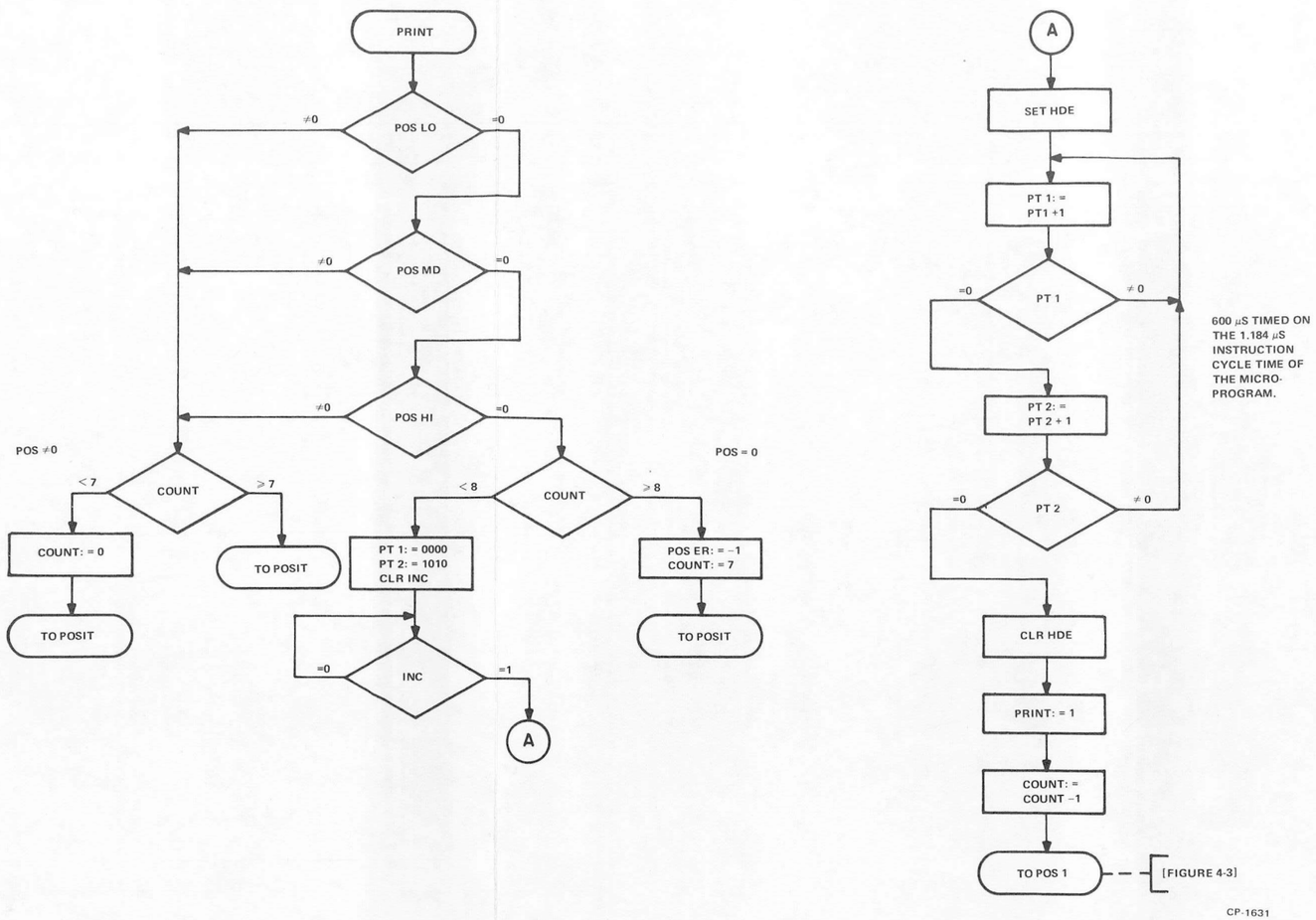


Figure 4-8 Print Routine

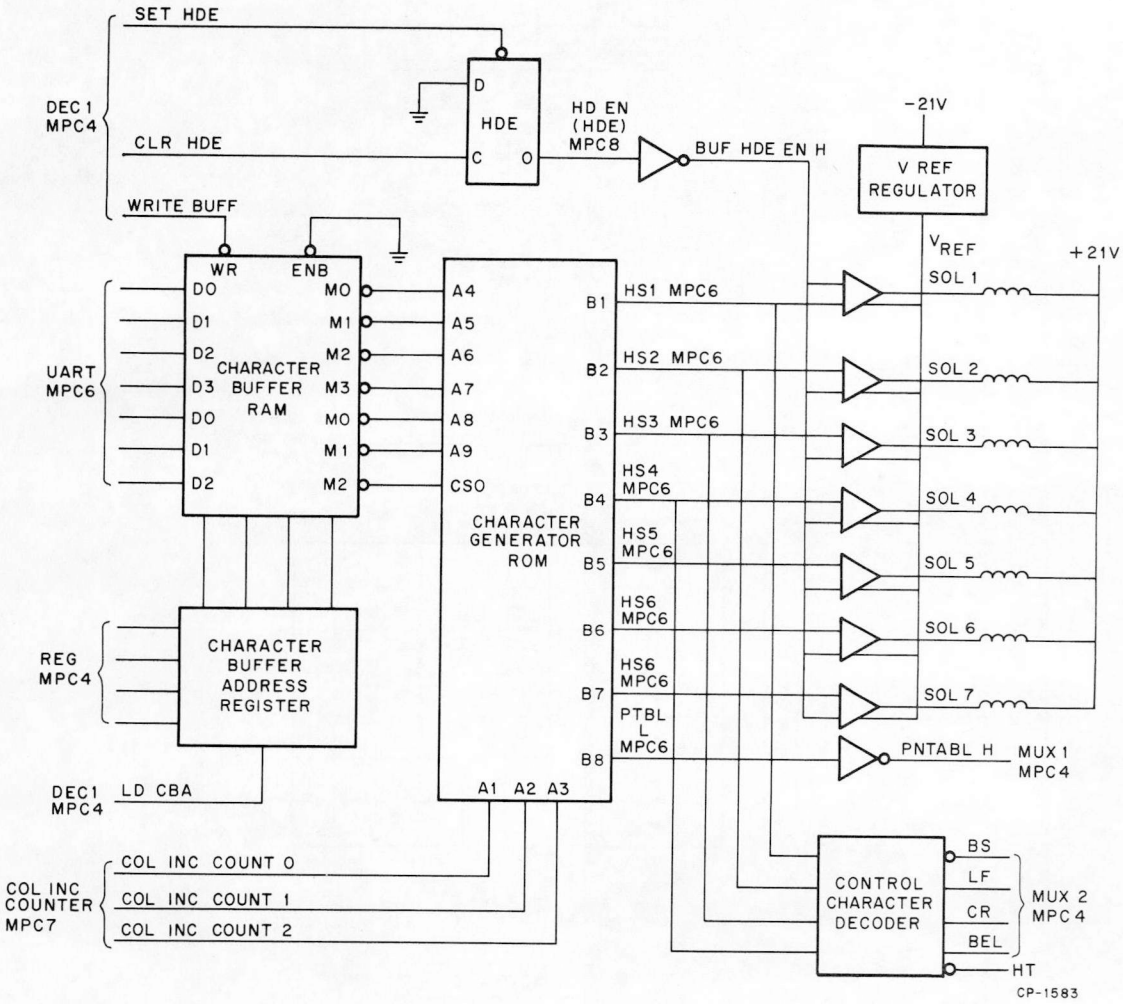


Figure 4-22 Character Buffer/Address Register/Generator and Print Head System

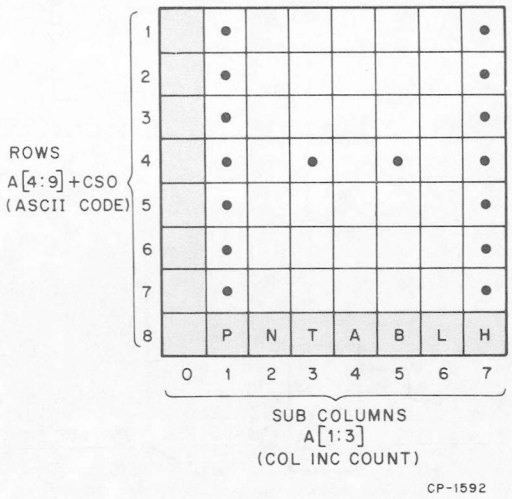


Figure 4-23 CG ROM Character Cell

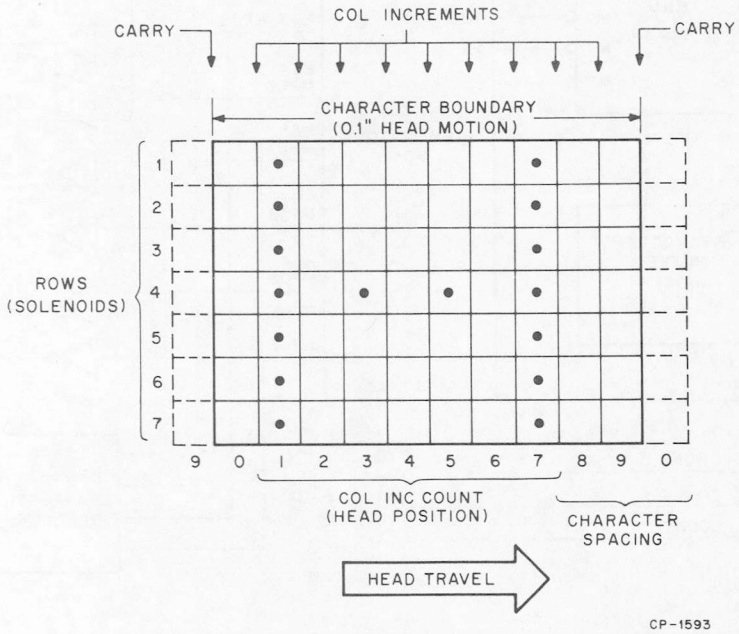


Figure 4-24 Print Head Operation

Table 4-7
LF Pulse Truth Table

	LF2	LF1
Hold	0	0
Step LF	0	1
Step LF	1	1
Step LF	1	0
Step LF	0	0

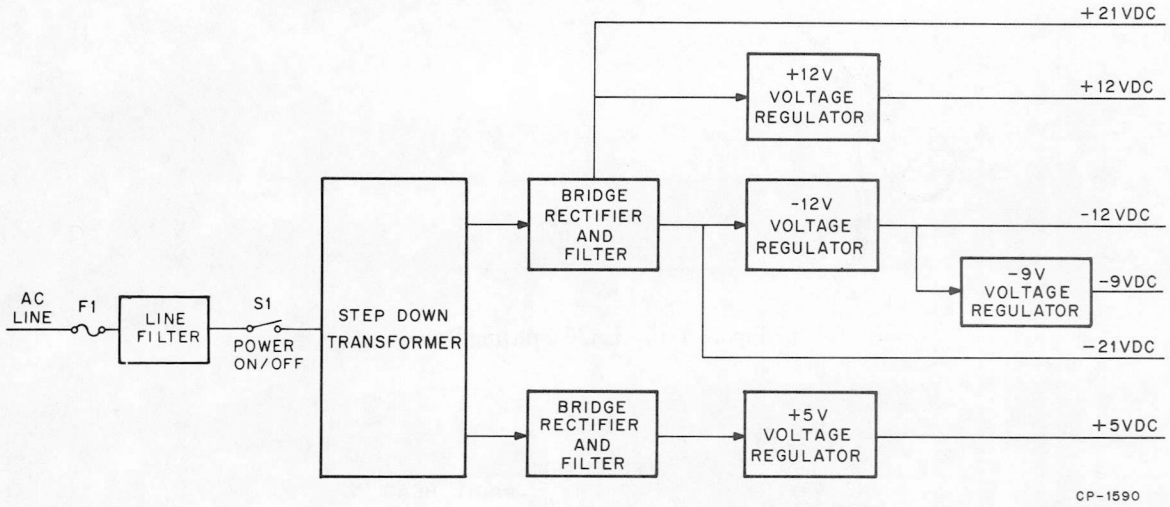


Figure 4-35 Power Supply Block Diagram

4.14.1 Carriage Subsystem

The Carriage Subsystem (Figure 4-37) includes the print head and the carriage which ride on the two support shafts that extend the full width of the printer mechanism. The carriage is driven by a timing belt which is held captive between the print head and the carriage and runs on a pulley at each end. The right-hand pulley is mounted on the dc servo motor, which provides the driving power for the carriage. The left-hand pulley is mounted on the ribbon drive shaft and transmits power to the Ribbon Feed Subsystem.

The carriage supports and positions the print head relative to the print bar and provides for adjustment of the paper gap by means of a detented adjustment lever on the right side of the carriage. Each detent position represents approximately 0.003 inch of gap and allows for a total of approximately 0.020 inch of paper gap.

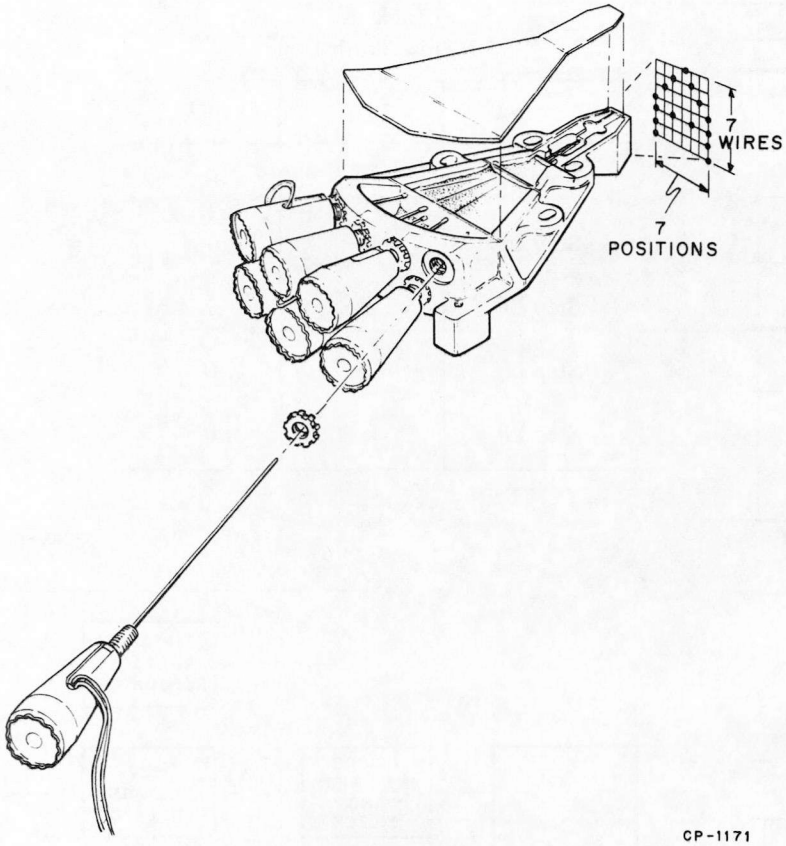


Figure 4-36 LA36 Printing Principle

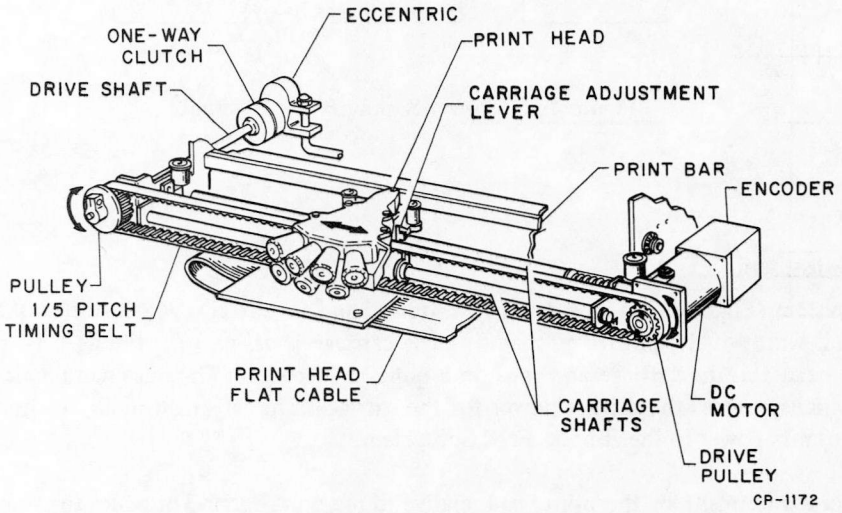
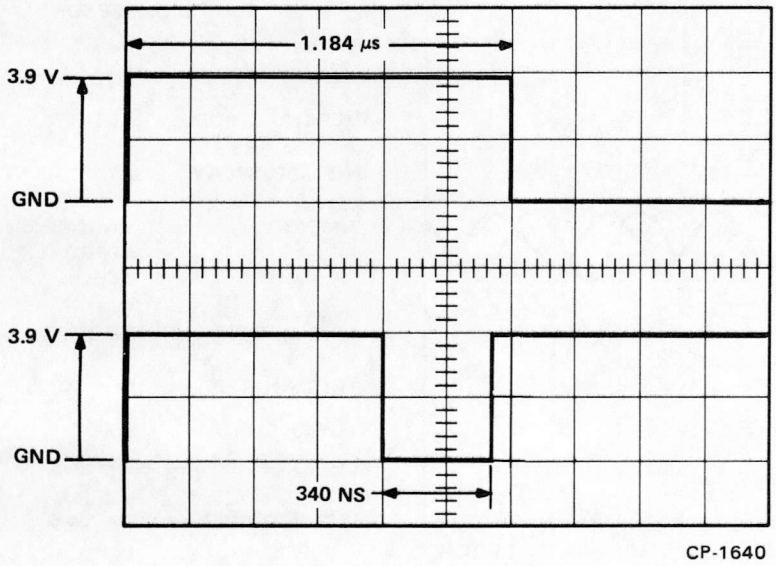


Figure 4-37 Carriage Subsystem



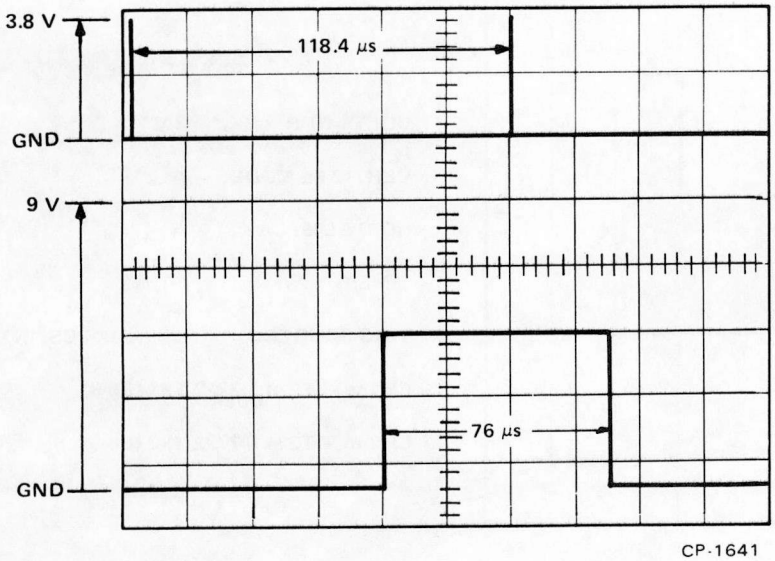
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	200 ns
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, INT, POS

CH1 to COUNT F/F at M7722 E4-9

CH2 to CLR +/- F/F at M7722 E9-6

Figure 5-7 COUNT Flip-Flop and CLR ± Flip-Flop Waveforms



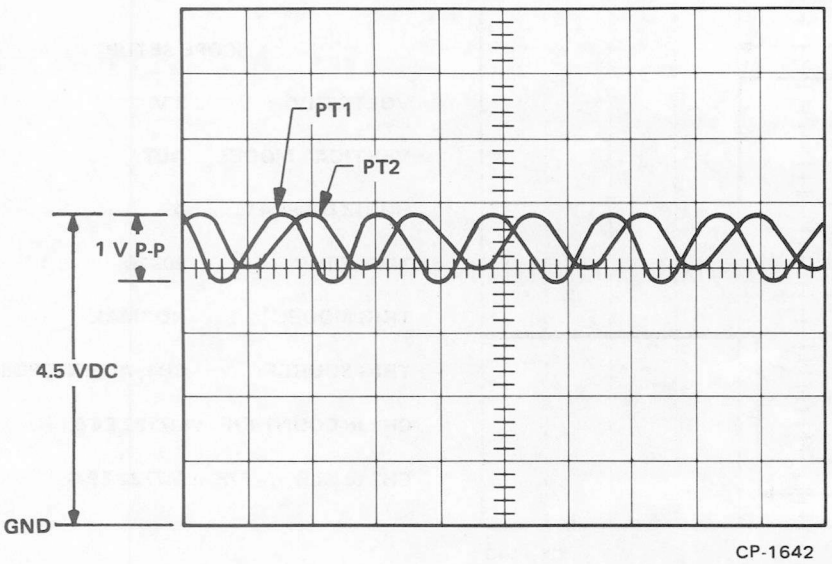
SCOPE SETUP

VOLTS/DIV:	CH1=2 V; CH2=5 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	20 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, INT, POS

CH1 to +INC at M7722 E8-9

CH2 to +TACH at M7722 Q11-C

Figure 5-8 +INC and +TACH Waveforms



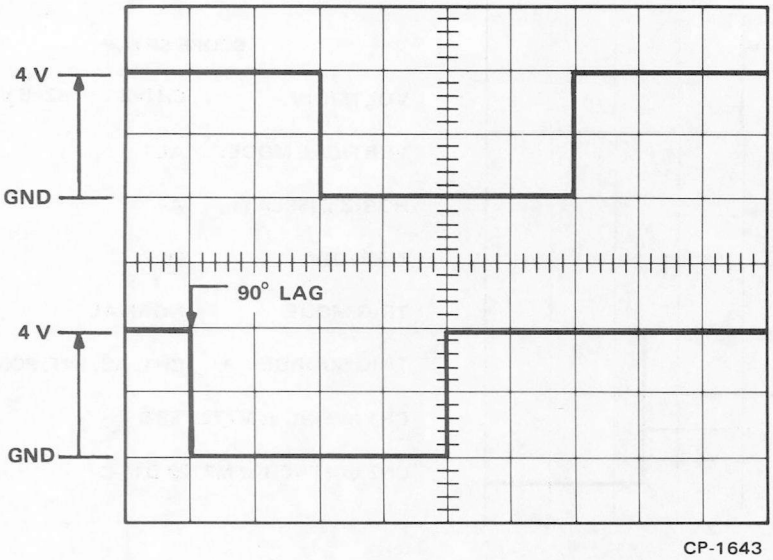
SCOPE SETUP

VOLTS/DIV:	1 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	VARIABLE–APPROX. 75 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, INT, POS

CH1 to PT1 at Power Board J4-5

CH2 to PT2 at Power Board J4-6

Figure 5-9 -PT1 and -PT2 Waveforms



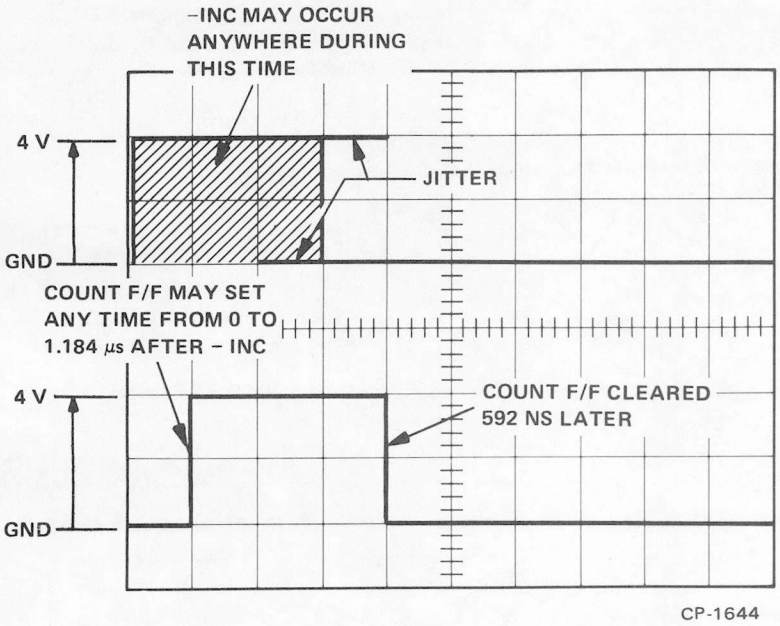
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 μs
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to -PT1 at M7722 TP1 (E6-8)

CH2 to -PT2 at M7722 TP2 (E6-6)

Figure 5-10 -PT1 and -PT2 Schmidt Waveforms



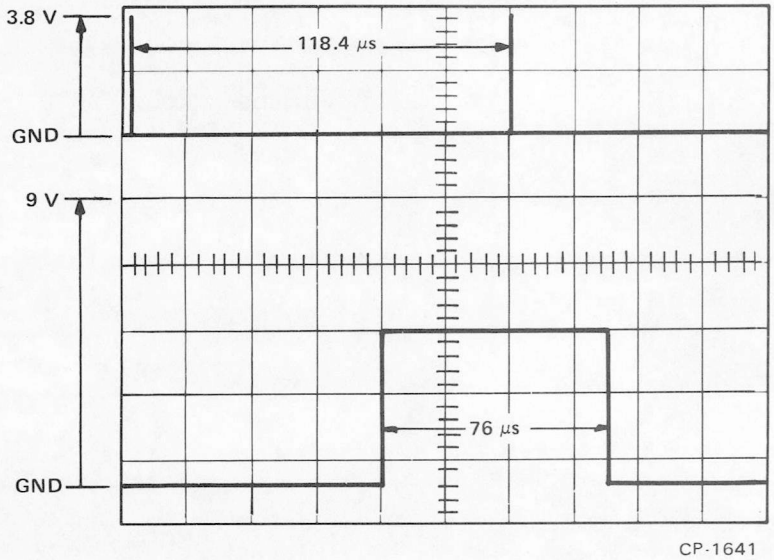
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	500 ns
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, INT, POS

CH1 to -INC at M7722 E8-5

CH2 to COUNT at M7722 E4-9

Figure 5-11 -INC and COUNT Flip-Flop Waveforms



SCOPE SETUP

VOLTS/DIV:	CH1=2 V; CH2=5 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	20 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, INT, POS

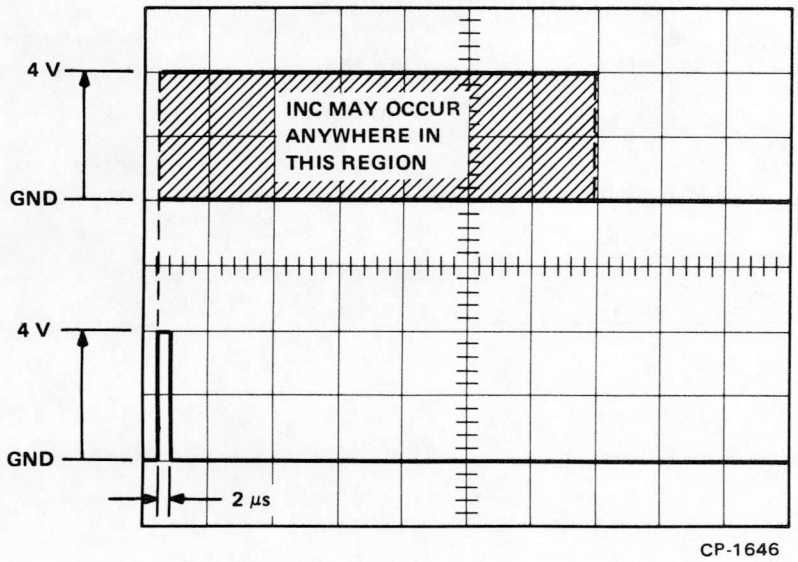
CH1 to -INC at M7722 E8-5

CH2 to -TACH at M7722 Q12-C

Figure 5-12 -INC and -TACH Waveforms

END OF ENCODER SIGNAL PROCESSING TEST WAVEFORMS

START OF SERVO SPEED TEST WAVEFORMS



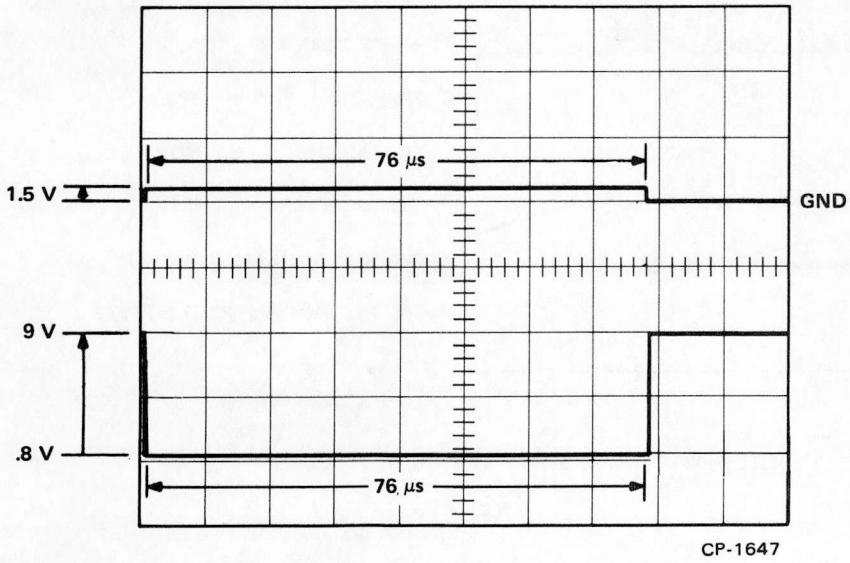
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to INC at M7722 E5-9

CH2 to 76 μs CLOCK at M7722 E5-11

Figure 5-13 – INC and 76 μs CLOCK Waveforms



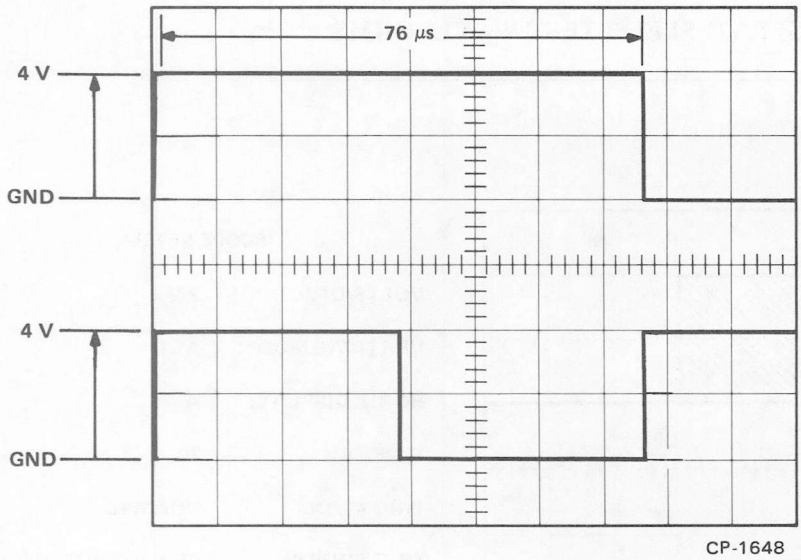
SCOPE SETUP

VOLTS/DIV:	5 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to TACH at M7722 Q12-B

CH2 to TACH at M7722 Q12-C

Figure 5-14 – TACH Waveforms at Q12-B and Q12-C



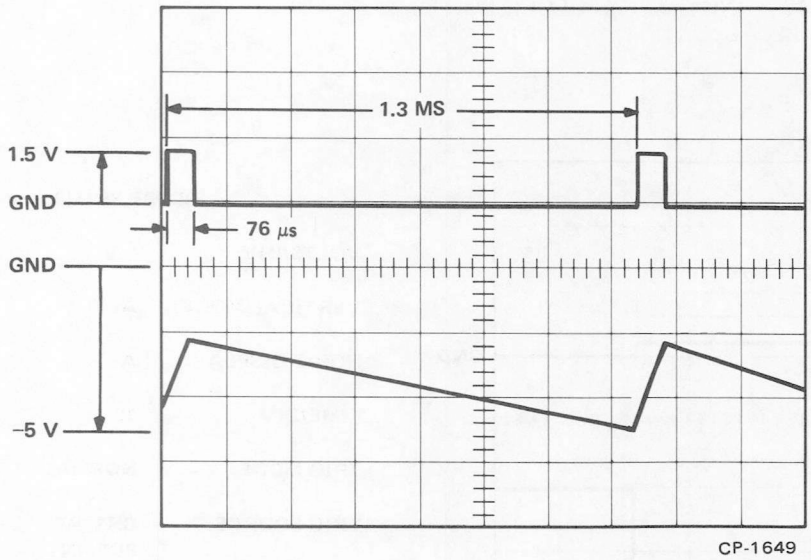
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to -TACH at M7722 E5-5

CH2 to 76 μs at M7722 E5-3

Figure 5-15 -TACH and 76 μs Waveforms



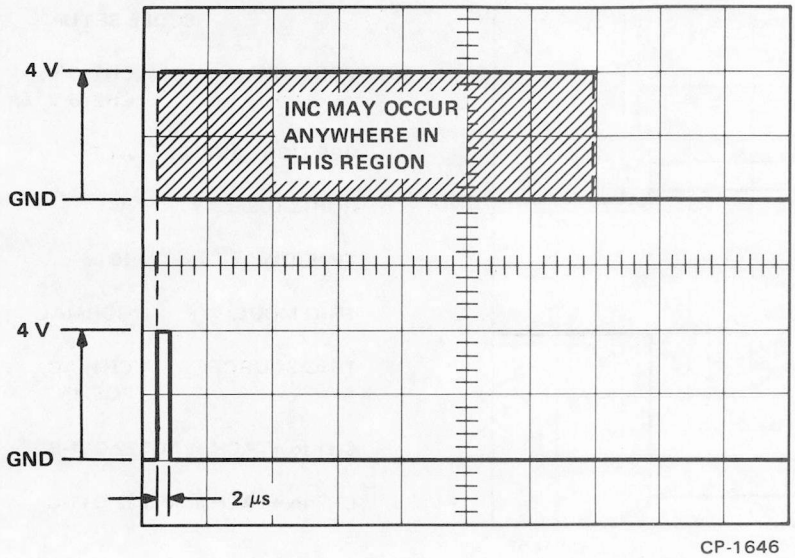
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	200 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to -TACH at M7722 Q12-B

CH2 to SUM at M7722 J1-B (E1-6)

Figure 5-16 -TACH Waveform and SUM Waveform at J1-B



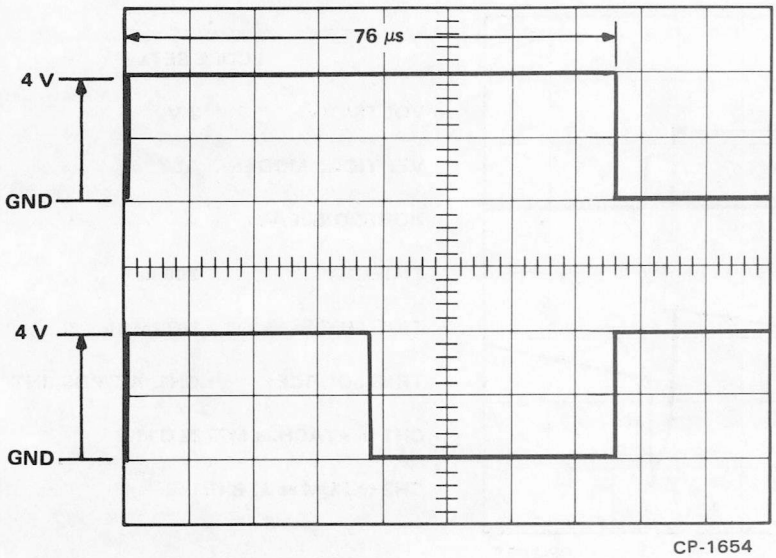
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to +INC at M7722 E3-9

CH2 to ~76 μs CLOCK at M7722 E3-11

Figure 5-21 +INC and 76 μs Waveforms



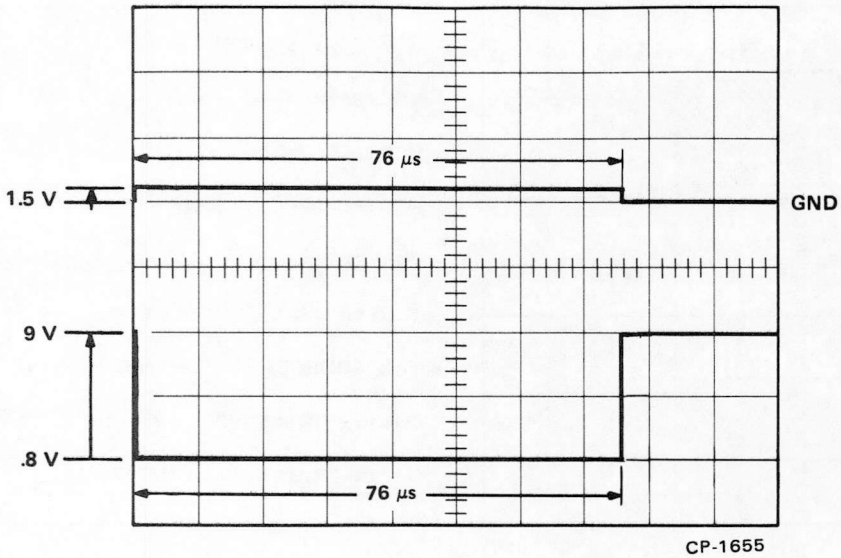
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to +TACH at M7722 E3-5

CH2 to 76 μs at M7722 E3-3

Figure 5-22 +TACH and 76 μs Waveforms



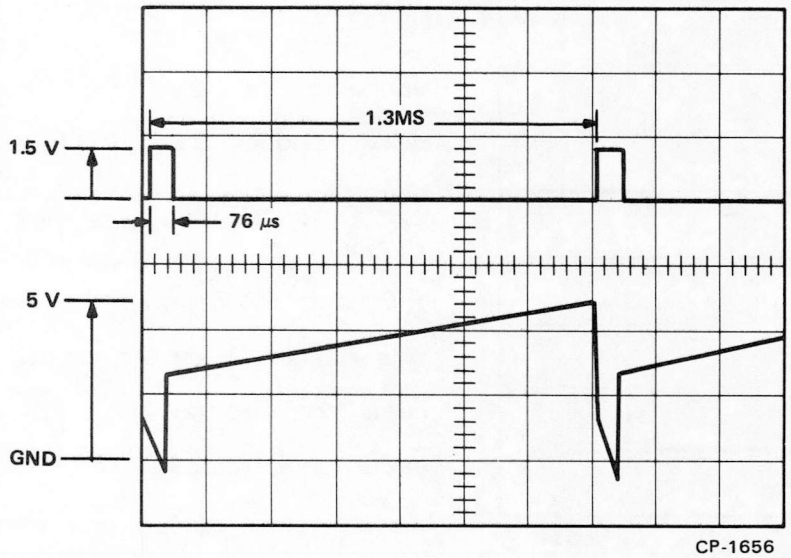
SCOPE SETUP

VOLTS/DIV:	CH1=5 V; CH2=5 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 µs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to +TACH at M7722 Q11-B

CH2 to +TACH at M7722 Q11-C

Figure 5-23 +TACH Waveforms at Q11-B and Q11-C



SCOPE SETUP

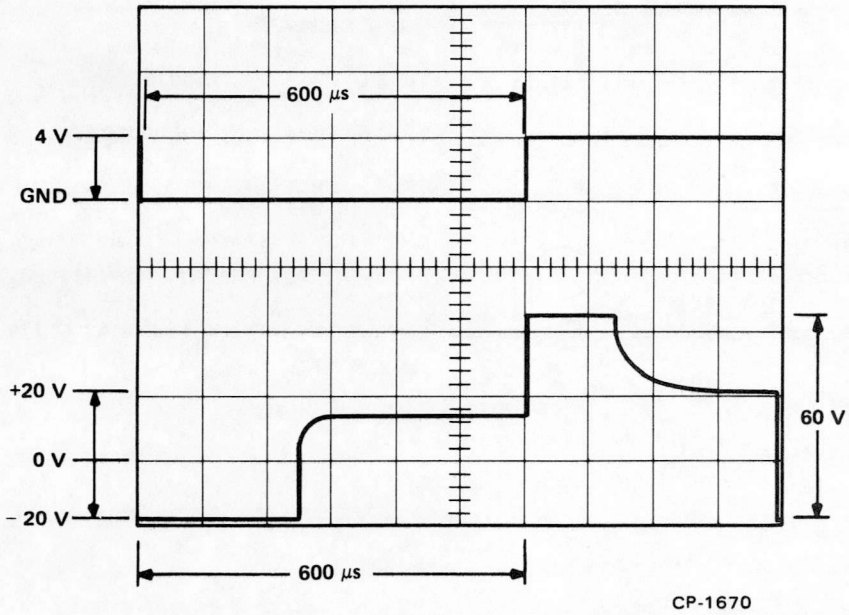
VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	200 µs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to +TACH at M7722 Q11-B

CH2 to SUM at J1-B (E1-6)

Figure 5-24 +TACH and SUM Waveforms at J1-B

START OF PRINTABLE CHARACTER TEST WAVEFORMS



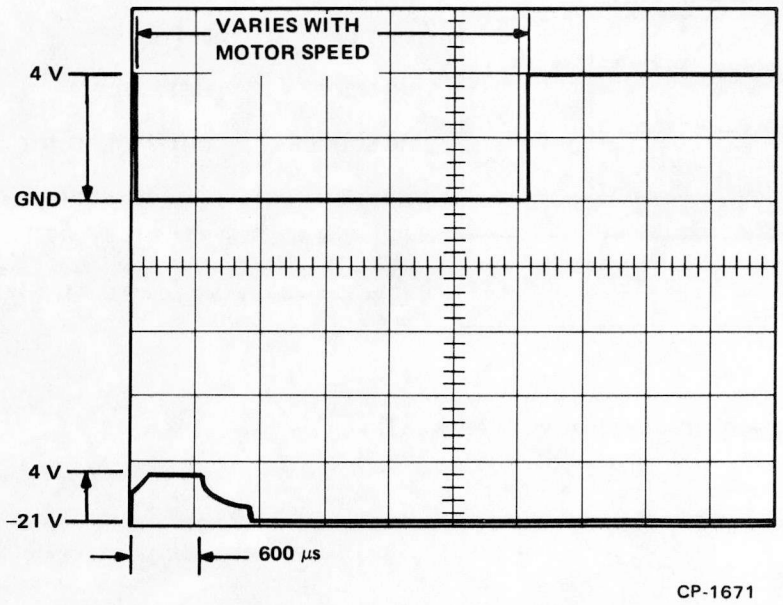
SCOPE SETUP

VOLTS/DIV:	CH1=2 V; CH2=20 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	100 µs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, NEG, INT

CH1 to HD EN at Power Board J1-4 (R58)

CH2 to SOL1 – SOL7 at Power Board J6 pins 8, 12, 4, 10, 18, 6 or 16 (Q17-C, Q19-C, Q1-C, Q20-C, Q18-C, Q16-C or Q21-C)

Figure 5-37 HD EN and SOL Waveforms at J6



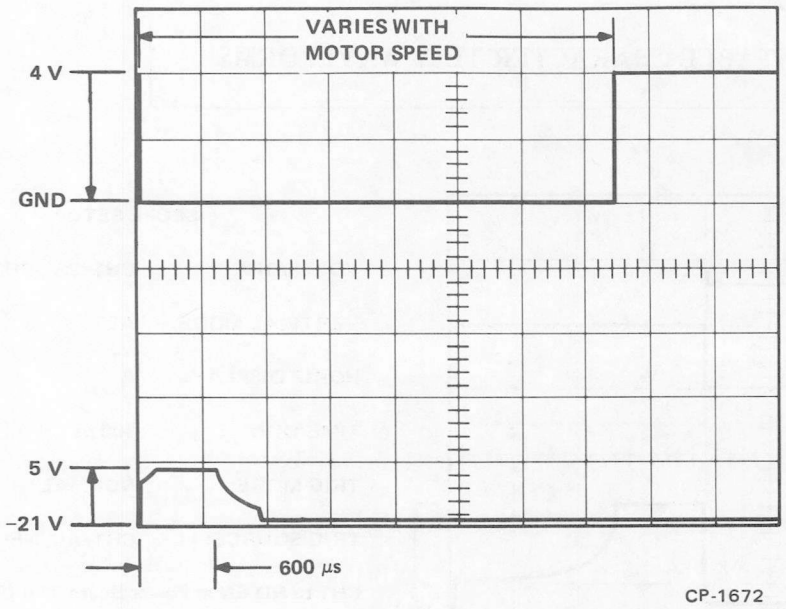
SCOPE SETUP

VOLTS/DIV:	CH1=2 V; CH2=5 V
VERTICAL MODE:	CHOP
HORIZ DISPLAY:	A
TIME/DIV:	500 µs
TRIG MODE:	HF REJECT
TRIG SOURCE:	CH1, AC, NEG, INT

CH1 to HS1 – HS7 at Power Board J1 (right side of R21, R49, R7, R28, R42, R15, and R35)

CH2 to SD1 – SD7 at test points P, V, Q2-E, B2, O, K, and A8

Figure 5-38 HS1 and SD1 Waveforms at TPP



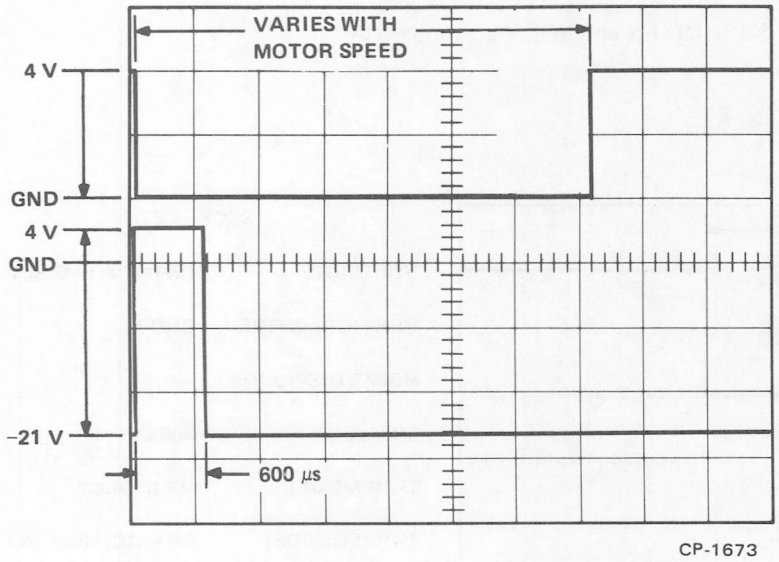
SCOPE SETUP

VOLTS/DIV:	CH1=2 V; CH2=5 V; AC-COUPLED
VERTICAL MODE:	CHOP
HORIZ DISPLAY:	A
TIME/DIV:	500 μs
TRIG MODE:	HF REJECT
TRIG SOURCE:	CH1, AC, NEG, INT

CH1 to HS1 – HS7 at Power Board J1 (right side of R49, R7, R28, R42, R21, R15 and R35)

CH2 to SD1 – SD7 at test points A3, D, Z, T, N, Q4-B, or A7

Figure 5-39 HS1 and SD1 Waveforms at TPN



SCOPE SETUP

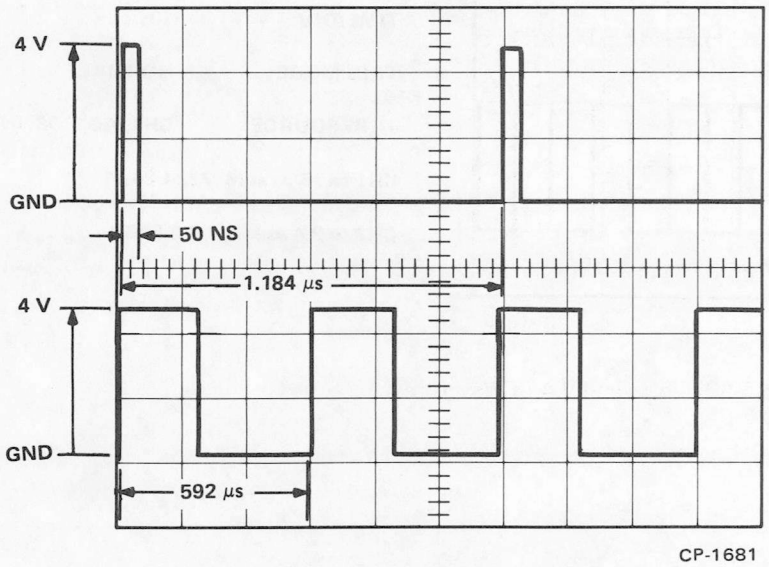
VOLTS/DIV:	CH1=2 V; CH2=10 V
VERTICAL MODE:	CHOP
HORIZ DISPLAY:	A
TIME/DIV:	500 μs
TRIG MODE:	HF REJECT
TRIG SOURCE:	CH1, AC, NEG, INT

CH1 to HS1 – HS7 at Power Board J1 (right side of R21, R49, R7, R28, R42, R15 and R35)

CH2 to SD1 – SD7 at test points L, A1, B, W, R, F or A5

Figure 5-40 HS1 and SD1 Waveforms at TPL

START OF CLOCK TEST WAVEFORMS



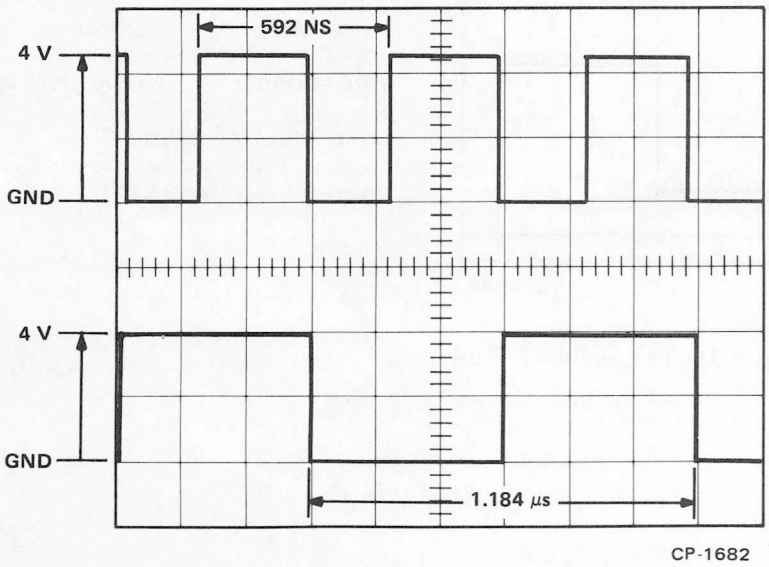
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	200 ns
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to CLK H at M7722 E64-5

CH2 to 592 ns at M7722 E64-10

Figure 5-48 CLK H and 592 ns Waveforms



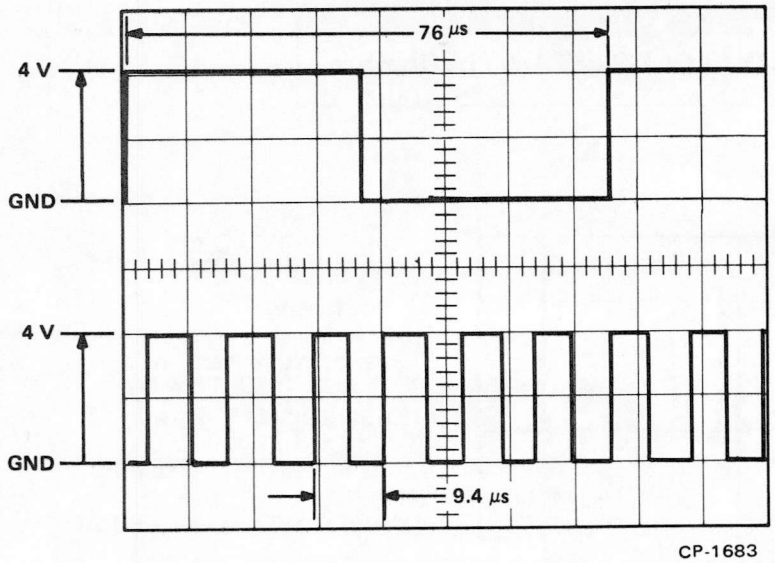
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	200 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to 592 ns at M7722 E13-14

CH2 to 1.184 us at M7722 E13-1

Figure 5-49 592 ns and 1.184 μs Waveforms



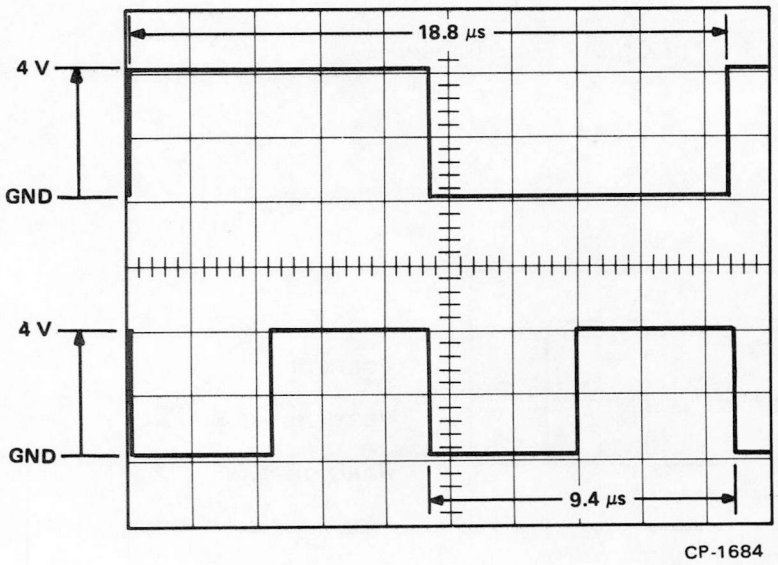
SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	10 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to 76 μs at M7722 E26-11

CH2 to 9.4 μs at M7722 E26-1

Figure 5-50 76 μs and 9.4 μs Waveforms



SCOPE SETUP

VOLTS/DIV:	2 V
VERTICAL MODE:	ALT
HORIZ DISPLAY:	A
TIME/DIV:	2 μs
TRIG MODE:	NORMAL
TRIG SOURCE:	CH1, AC, POS, INT

CH1 to 19L at M7722 E26-9

CH2 to 9.4 μs at M7722 E26-1

Figure 5-51 19 L and 9.4 μs Waveforms